Testing a lattice with a smaller vertical beta function in the insertion device straights

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Several benefits can be realized when operating the ALS with a reduced vertical beta function in the insertion device straight sections: small beta functions reduce the influence of insertion device movements on the closed orbit, the betatron tunes (and therefore beam size) and the beta beating. In addition smaller beta functions can provide longer lifetimes if it is limited due to the height of insertion device gaps (which is the case at the ALS particularly at 1.5 GeV). Finally in most cases smaller beta functions increase the brightness since it matches the electron ellipse in phase space better to the photon beam emittance. Possible disadvantages include the possibility of a reduced dynamic aperture which can impact injection efficiency and lifetime. Furthermore the increased angular spread of the electron beam can generate an inhomogeneous spectral broadening of undulator radiation.

Based on these considerations a lattice with a vertical beta function of about 2.4 m at the center of each insertion device straight was created for the ALS. The design beta function is about 4 m. In this lattice the vertical tune is higher by exactly one unit (9.18 compared to 8.18). Calculations for this lattice show that both possible negative effects mentioned above are negligible. The dynamic aperture reduction was found to be insignificant and this is not surprising considering that the sextupole strengths necessary to compensate the chromaticity remained nearly the same for the two lattices. The spectral broadening is also insignificant and would only become significant for beta functions smaller than 1 m. Figure 1 shows the beta function and dispersion function of the new lattice compared to the old one.

Figure 2 shows the increase in brightness for the new lattice, calculated for different lengths of insertion devices (EPU 1.85 m, Wiggler 3.05 m, U5 4.45 m). For the calculation no spectral broadening, zero dispersion and zero alpha function at the ID center, zero detuning of the undulator and emittances of 5.5 nm rad horizontally and 0.2 nm rad vertically were assumed.

We began to explore the 2.4m beta function lattice in November and the results are very encouraging so far. The injection efficiency is unchanged compared to the nominal lattice. Response matrix measurements and phase advance measurements showed that the symmetry of the new lattice is as good as for the old one and that the optical functions of the new lattice are very close to the intended ones. Lifetime measurements showed that a significant increase in lifetime could be achieved. The increase with all skew quadrupoles off was larger than 50%, both at 1.5 and at 1.9 GeV. In addition the influence of insertion device motion on beam size and orbit was significantly reduced.

Operational disadvantages, which are under investigation, are mostly related to coupling. One example is that the tilt of the beam axis at the synchrotron light monitor (Beamline 3.1) is larger in the new lattice than in the old one. It has to be studied whether this is representative for the rest of the ring and how it can be corrected. In addition the skew quadrupoles in their present

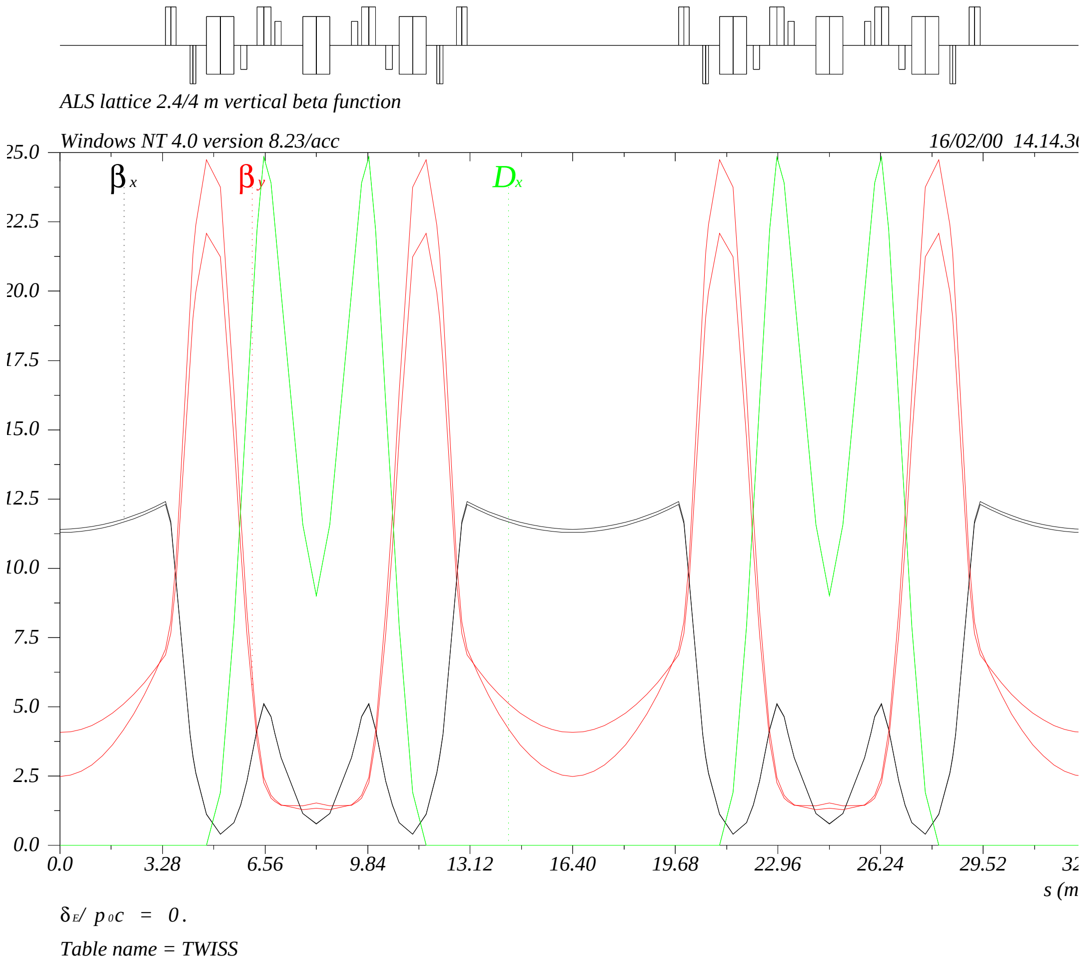

Figure 1. Comparison of the optical functions of the nominal ALS lattice and a lattice with a reduced vertical beta function of 2.4 m in the insertion device straights.

configuration cannot be used to control (increase) the emittance in the new lattice since the coupling resonance close to the new working point is suppressed by symmetry. But even without artificially increasing the coupling, the lifetime at 1.9 GeV with the insertion devices closed was slightly higher than in the old lattice with increased vertical emittance.

After these studies will be completed and insertion device orbit feed forward schemes are modified to work together with the new lattice it will be tested together with the user community to detail the exact impact on the beamlines.

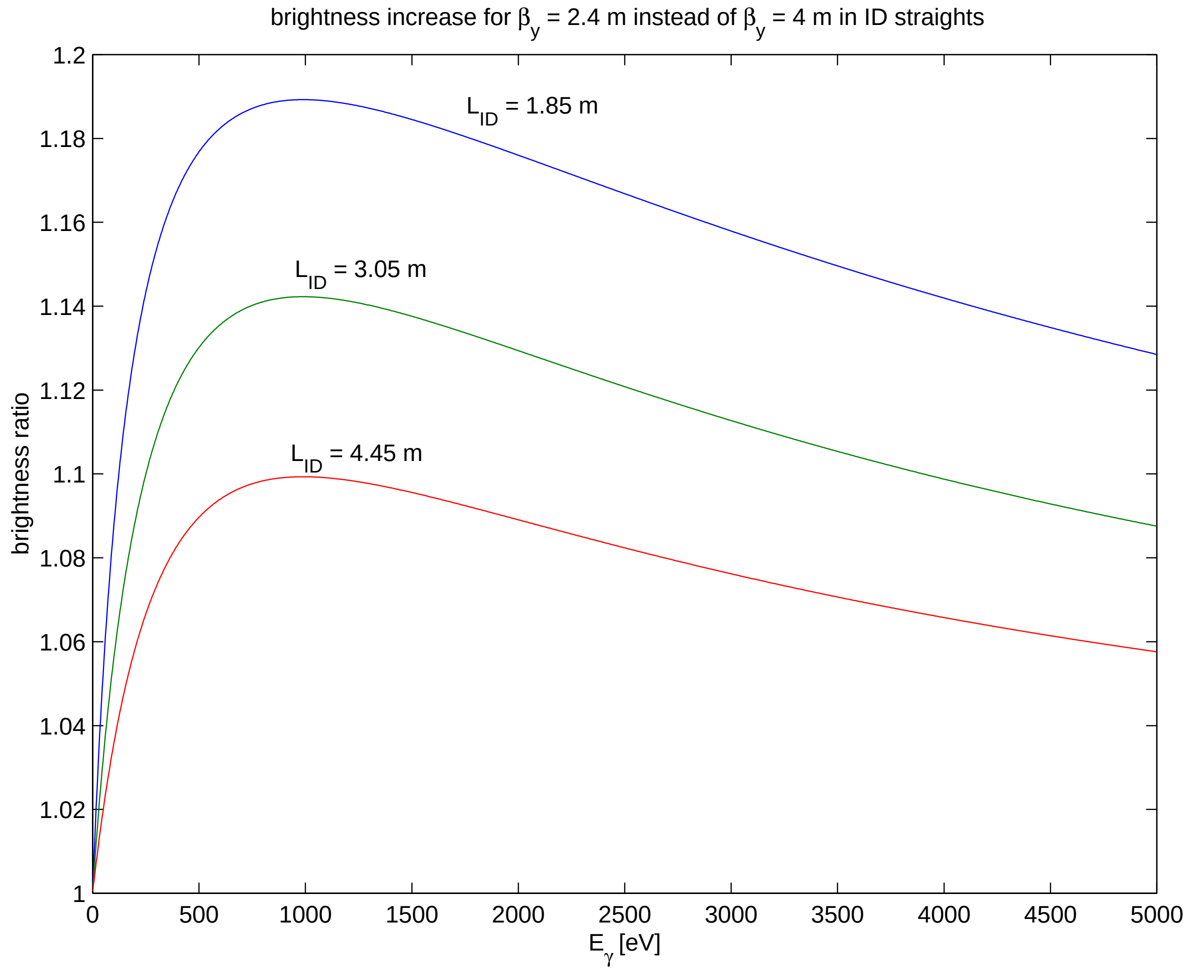

Figure 2. Comparison of the brightness of insertion devices for the nominal ALS lattice and a lattice with a reduced vertical beta function of 2.4 m in the insertion device straights (assuming a horizontal emittance of 5.5 nm rad and a vertical of 0.2 nm rad).

This work was supported by the Director, Office of Energy Research, Office of Basic Energy Sciences, Materials Science Division, of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

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